US009477050B2

(12) **United States Patent**
Megason et al.

(10) **Patent No.: US 9,477,050 B2**
(45) **Date of Patent: Oct. 25, 2016**

(54) **CONNECTOR MODULES HAVING OPTICAL CONNECTORS MOVEABLE BETWEEN A RETRACTED POSITION AND AN EXTENDED POSITION**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/976,180**

(22) Filed: **Dec. 21, 2015**

(65) **Prior Publication Data**

US 2016/0103285 A1 Apr. 14, 2016

Related U.S. Application Data

(63) Continuation of application No. 14/370,165, filed as application No. PCT/US2012/020434 on Jan. 6, 2012, now Pat. No. 9,217,832.

(51) **Int. Cl.**
G02B 6/10 (2006.01)
G02B 6/38 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G02B 6/3897*** (2013.01); ***G02B 6/3628*** (2013.01); ***G02B 6/4261*** (2013.01); ***G02B 6/4292*** (2013.01); ***G02B 6/43*** (2013.01); ***G02B 6/4452*** (2013.01); *Y10T 29/49826* (2015.01)

(58) **Field of Classification Search**
CPC G02B 6/4292; G02B 6/4246; G02B 6/4201; G02B 6/4452; G02B 6/3897; G02B 6/4454; Y02E 30/40; B21D 53/88; B23O 15/00
USPC 385/88–89, 92, 134–135; 29/428
See application file for complete search history.

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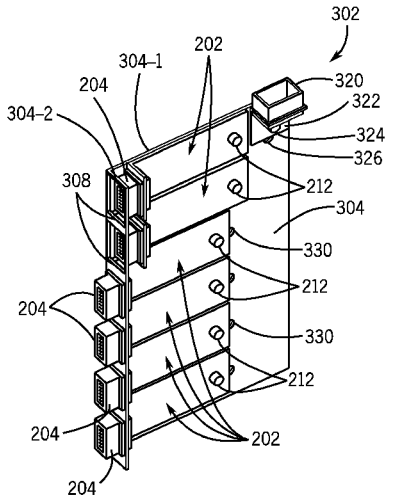
(74) *Attorney, Agent, or Firm* — Trop, Pruner & Hu, P.C.

(57) **ABSTRACT**

A plurality of connector modules are mounted to a support frame. The connector modules have respective optical connectors to optically connect with respective electronic devices, where the optical connectors are moveable between a retracted position and an extended position. The optical connector of a first of the connector modules is retractable and extendable independently of a second of the connector modules.

18 Claims, 7 Drawing Sheets



(51) **Int. Cl.**

G02B 6/42	(2006.01)
G02B 6/43	(2006.01)
G02B 6/36	(2006.01)
G02B 6/44	(2006.01)

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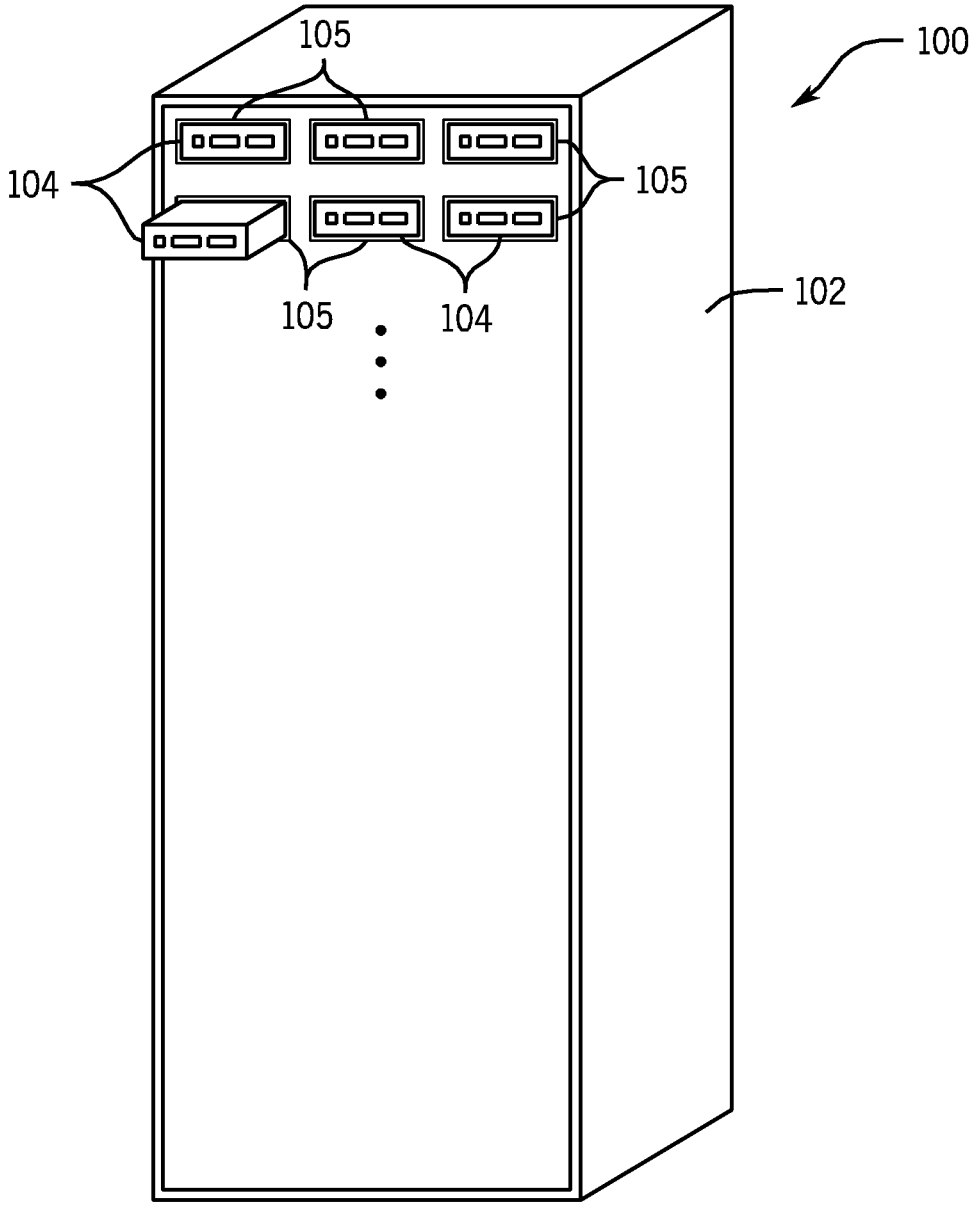

FIG. 1

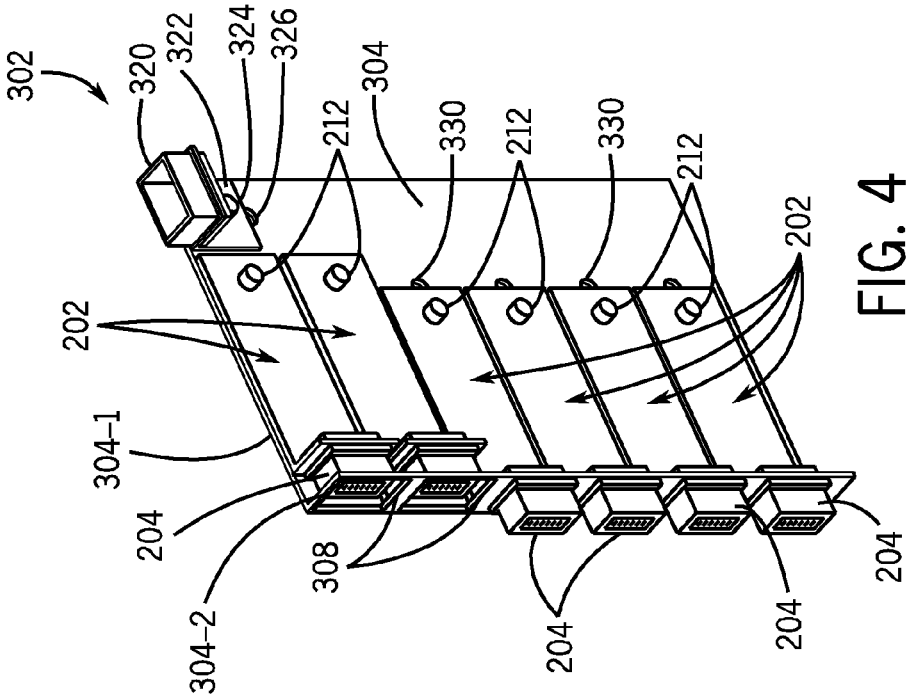

FIG. 4

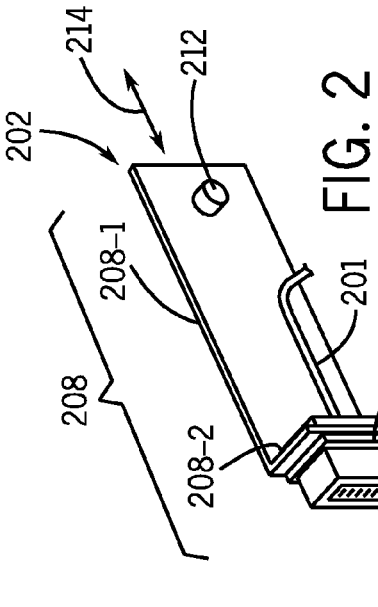

FIG. 2

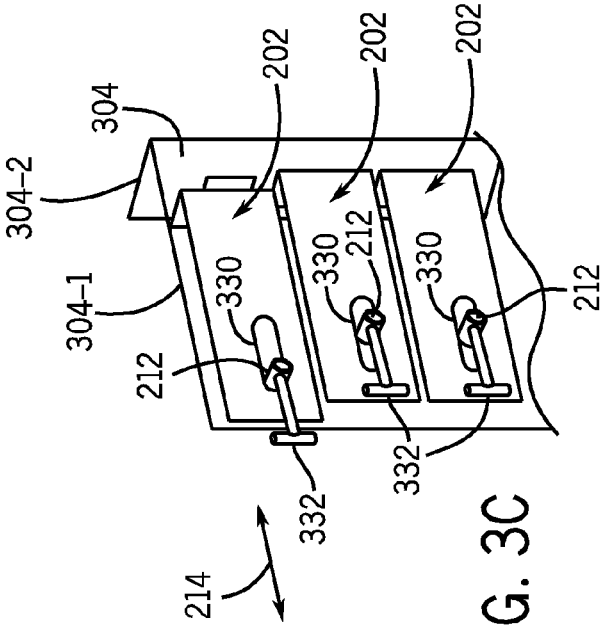

FIG. 3C

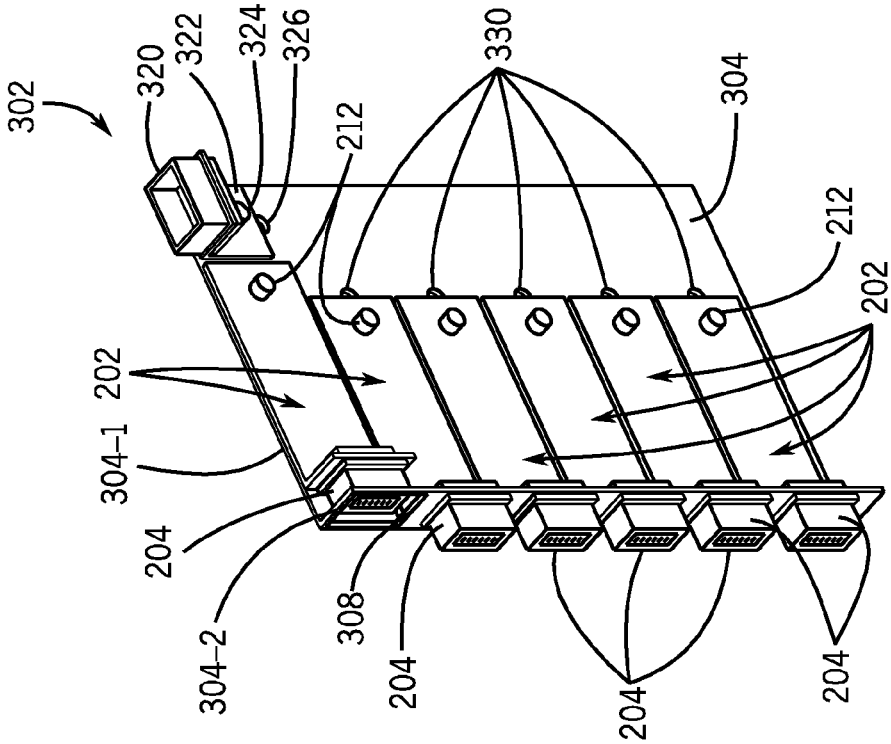
302
320
322
324
326
330
304
212
202
304-1
204
304-2
308

FIG. 3B

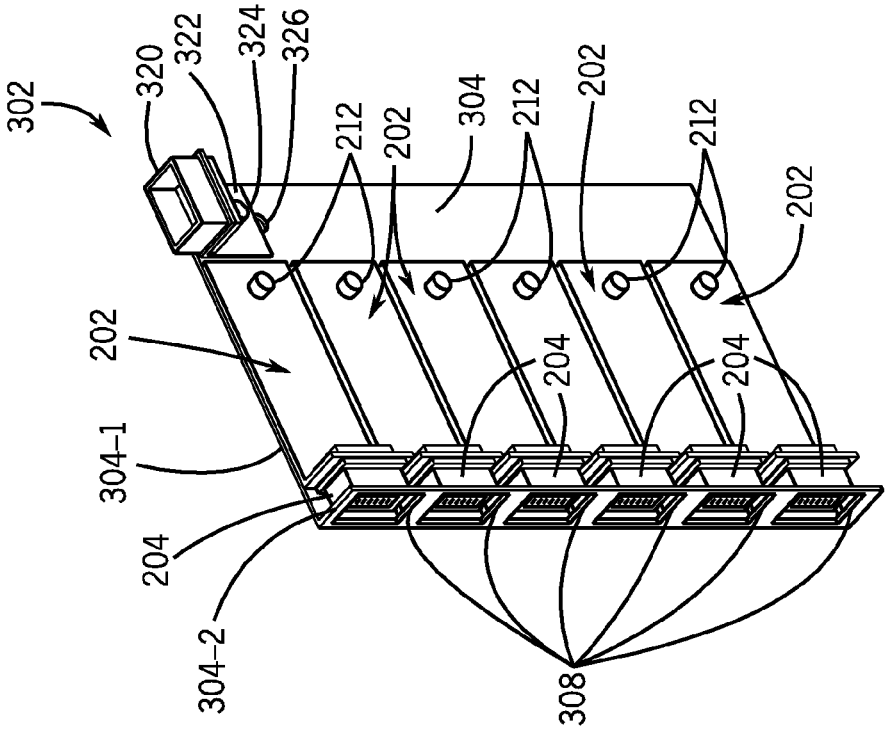
302
320
322
324
326
212
202
304
212
202
212
202
304-1
204
304-2
308

FIG. 3A

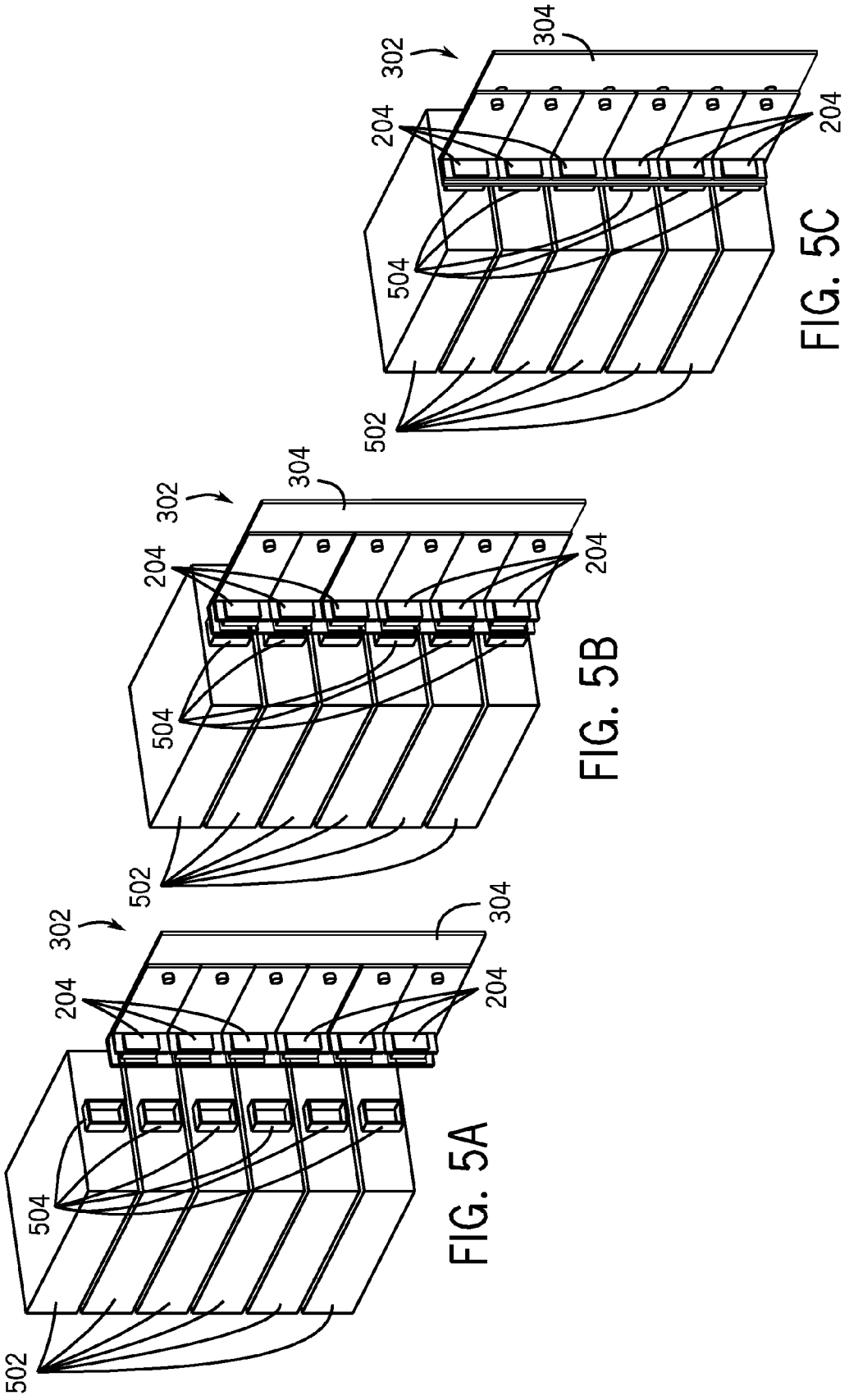

FIG. 5C

FIG. 5B

FIG. 5A

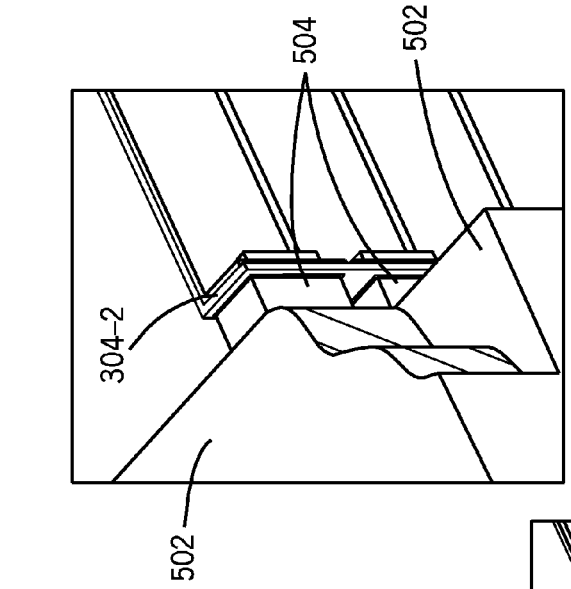

FIG. 6C

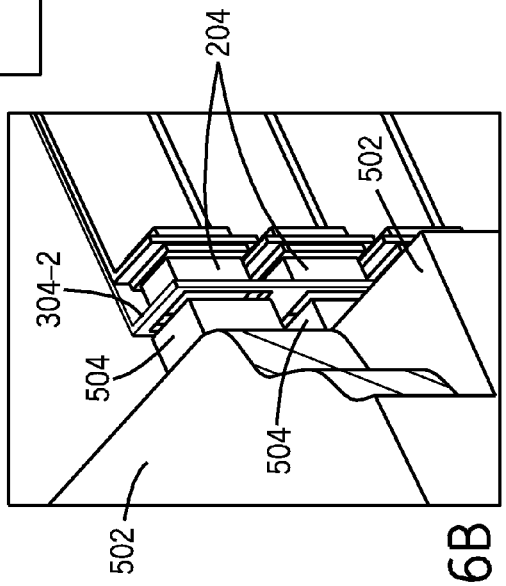

FIG. 6B

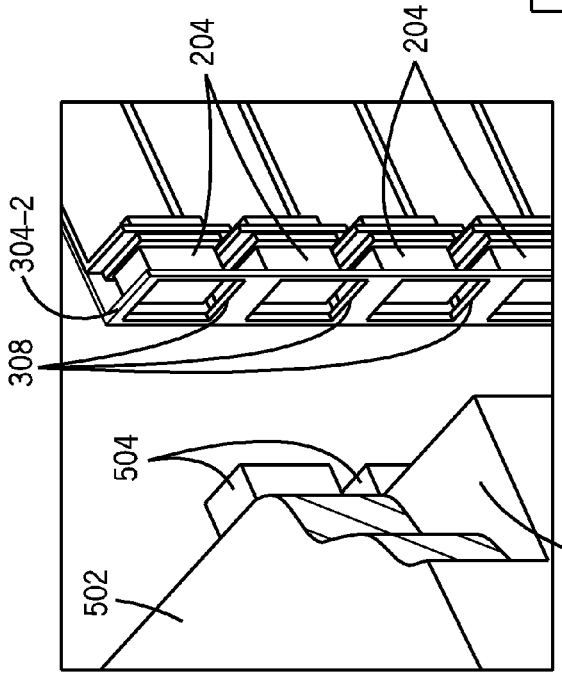

FIG. 6A

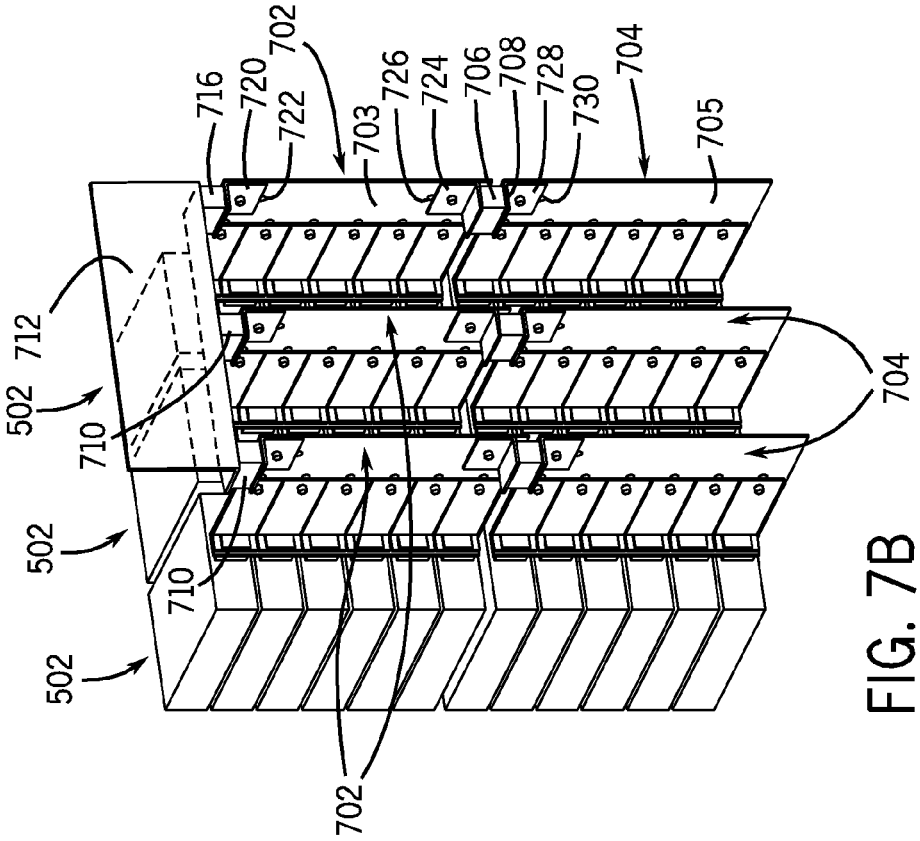
716
720
722
702
703
726
724
706
708
728
730
704
705
712
502
710
502
710
502
704
702

FIG. 7B

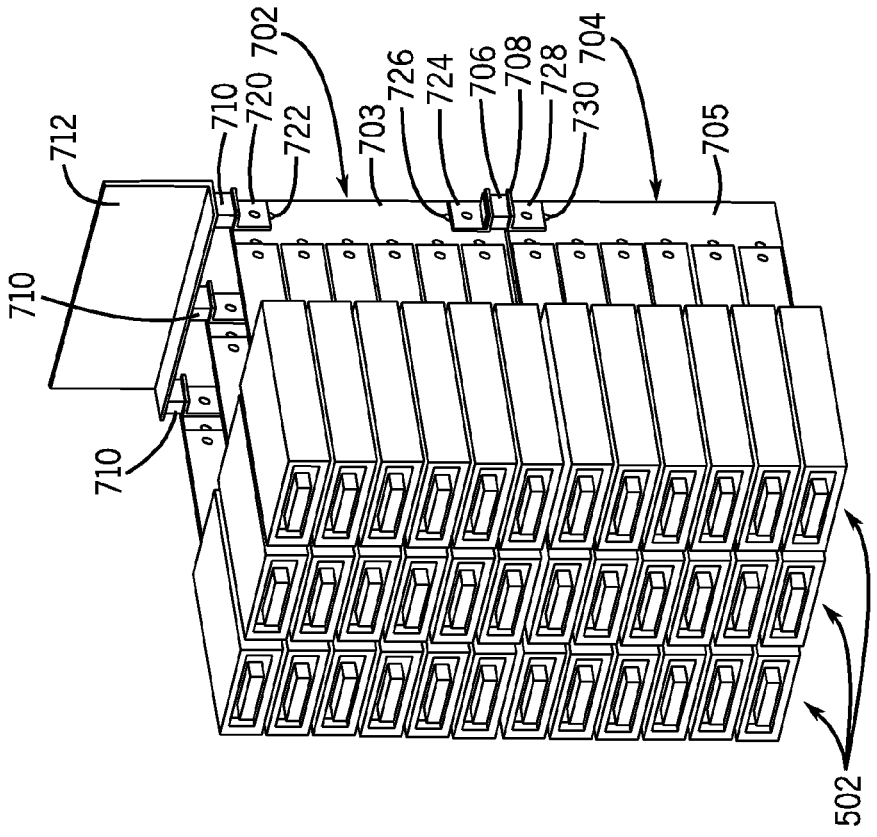
712
710
720
722
702
703
726
724
706
708
728
730
704
705
710
710
502

FIG. 7A

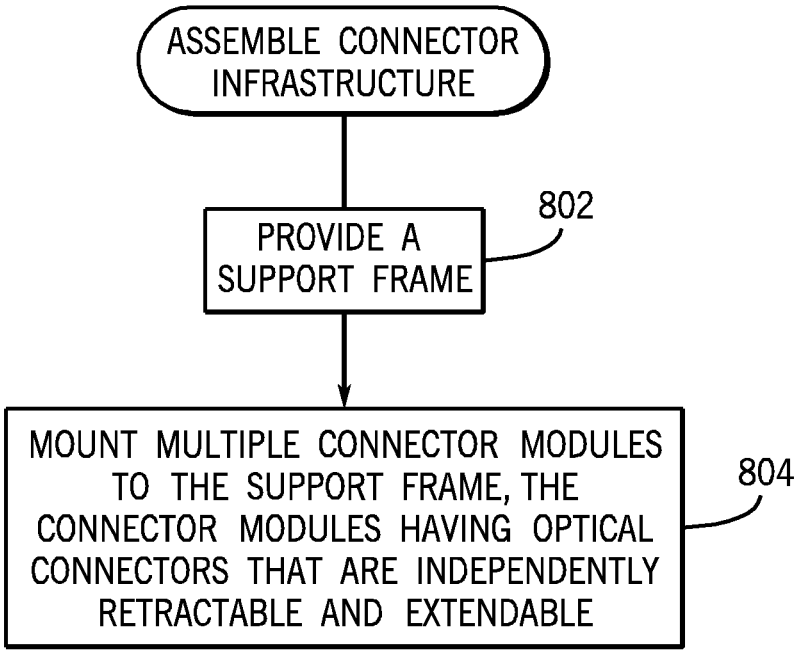
ASSEMBLE CONNECTOR INFRASTRUCTURE
PROVIDE A SUPPORT FRAME
802
MOUNT MULTIPLE CONNECTOR MODULES TO THE SUPPORT FRAME, THE CONNECTOR MODULES HAVING OPTICAL CONNECTORS THAT ARE INDEPENDENTLY RETRACTABLE AND EXTENDABLE
804

FIG. 8

CONNECTOR MODULES HAVING OPTICAL CONNECTORS MOVEABLE BETWEEN A RETRACTED POSITION AND AN EXTENDED POSITION

CROSS REFERENCE TO RELATED APPLICATIONS

This is a continuation of U.S. application Ser. No. 14/370,165, filed Jul. 1, 2014, which is a national stage application under 35 U.S.C. §371 of PCT/US2012/020434, filed Jan. 6, 2012, both hereby incorporated by reference.

BACKGROUND

A system can include multiple electronic devices. To allow communication with the electronic devices, a backplane infrastructure can be provided in the system, where the backplane infrastructure has connectors to connect with respective mating connectors of the electronic devices. The connectors of the backplane infrastructure can include optical connectors to optically connect to respective electronic devices.

BRIEF DESCRIPTION OF THE DRAWINGS

Some embodiments are described with respect to the following figures:

FIG. **1** is a schematic perspective view of a rack including electronic devices according to some implementations;

FIG. **2** is a perspective view of a connector module according to some implementations;

FIGS. **3**A-**3**B are perspective views of a first side of a connector infrastructure having connector modules according to some implementations;

FIG. **3**C is a perspective view of a second, opposite side of the connector infrastructure of FIG. **3**B;

FIG. **4** is a perspective view of a connector infrastructure according to alternative implementations;

FIGS. **5**A-**5**C and **6**A-**6**C illustrate an example of connecting a connector infrastructure according to some implementations with an arrangement of electronic devices;

FIGS. **7**A-**7**B are different perspective views of an example system that has electronic devices and connector infrastructures according to some implementations; and

FIG. **8** is a flow diagram of assembling a connector infrastructure according to some implementations.

DETAILED DESCRIPTION

Electronic devices, such as processing devices, storage devices, communications devices, management devices, and so forth, can be mounted in a rack, which includes a frame and other support elements for holding the electronic devices. The rack provides receptacles into which the electronic devices can be inserted. The rack can also include a backplane infrastructure for connection to the electronic devices that have been inserted into the rack. Generally, the backplane infrastructure can include a support structure to which connectors are attached. When electronic devices are mounted in the rack, connectors on the electronic devices can mate with connectors of the backplane infrastructure. The connectors of the backplane infrastructure are connected to communications media (e.g. optical fibers, electrical wires, etc.) to allow for communication with the electronic devices.

A backplane infrastructure can include optical connectors for optical connection with respective optical connectors of the electronic devices. It is noted that the electronic devices and the connector infrastructure can also include electrical connectors for electrically connecting the electronic devices to the backplane infrastructure. In the ensuing discussion, reference is made to just optical connectors—note, however, that it is to be understood that various components discussed below can also additionally include electrical connectors.

In some examples, a backplane infrastructure can include an integrated and fixed arrangement of optical connectors for connection to respective electronic devices. An integrated and fixed arrangement of optical connectors refers to an arrangement in which the optical connectors are affixed to a support structure of the backplane infrastructure such that the optical connectors have to be connected to or disconnected from all electronic devices in a system at the same time. This can present an issue when the backplane infrastructure is to be accessed for service (e.g. to repair a defective component) or upgrade (e.g. to replace a component). Having to connect and disconnect a relatively large number of mating optical connectors in a system can result in damage to optical connectors in some cases.

In accordance with some implementations, a connector infrastructure is provided that has multiple connector modules having respective optical connectors, where the connector modules are each moveable between a retracted position (a position in which the respective optical connector is retracted within a support frame of the connector infrastructure) and an extended position (a position in which at least a portion of the optical connector is exposed and outside the support frame of the connector infrastructure to allow for mating with a respective optical connector of an electronic device). Multiple ones of the connector modules are independently actuatable between the retracted position and the extended position, such that some of the connector modules can be in the extended position while others of the connector modules are in the retracted position. In this way, a user can selectively connect some (less than all) of the optical connectors of the connector infrastructure to respective electronic devices mounted in a system. This provides flexibility to allow a user to select which connector module to optically connect to a corresponding electronic device. Also, since less than all optical connectors can be connected or disconnected at one time, the likelihood of damage to an optical connector during connection or disconnection between connector modules and electronic devices is reduced.

Also, during installation of a connector infrastructure according to some implementations, a user can mount the connector infrastructure in the system with the connector modules in their retracted position. After the connector infrastructure has been mounted in the system, a user can incrementally move respective connector modules to their extended position to connect to respective electronic devices. In this way, not all of the optical connectors of the connector infrastructure have to be connected to the electronic devices in the system at one time during connector infrastructure installation, which can reduce the likelihood of damage to optical connectors. Also, better final alignment of the mating optical connectors can be achieved by independently mating the optical connectors.

FIG. **1** illustrates an example system **100** that has a rack **102** that includes various electronic devices **104**. The rack **102** includes an external chassis (or frame) containing receptacles **105** into which respective electronic devices **104** can be inserted. Although not shown in FIG. **1**, the rear

portion of the rack **102** includes a connector infrastructure having connector modules for connecting to electronic devices that have been mounted in the rack **102**.

FIG. **2** shows a connector module **202** that has an optical connector **204** for connection to a mating optical connector of a respective electronic device (e.g. **104** in FIG. **1**). The optical connector **204** has optical elements **206**, which can include ferrules. Generally, a "ferrule" of an optical connector refers to an interface for an optical fiber (such as optical fiber **201** depicted in FIG. **2**), where the interface allows for optical communication between the optical fiber and another optical component. Although just one optical fiber **201** is depicted in FIG. **2**, note that there can be multiple optical fibers in the connector module **202** that are connected to respective ferrules **206** of the optical connector **204**. Moreover, the optical connector **204** can also include various lenses and other optical components to allow for optical communications.

As further shown in FIG. **2**, the connector module **202** includes a slider **208** that has a first segment **208-1** and a second segment **208-2** that is angled (e.g. generally perpendicular) to the first segment **208-1**. The second segment **208-2** has an opening through which the optical connector **204** is mounted, such that the optical connector **204** passes through the opening of the second segment **208-2**. An attachment mechanism **210** attaches the optical connector **204** to the second segment **208-2** of the slider **208**.

As further depicted in FIG. **2**, an actuator **212** (which can be in the form of a knob, handle, and so forth) is mounted to the first segment **208-1** of the slider **208**. The actuator **212** protrudes from the main surface of the first segment **208-1** of the slider **208** to allow for a user to grip the actuator **212** to move the slider **208** in a longitudinal direction **214** of the first segment **208-1** of the slider **208**. Note that the actuator **212** also protrudes from the opposite surface of the first segment **208-1**, as depicted in FIG. **3**C (discussed further below).

In other implementations, other types of sliders (having configurations different from the configuration of the slider **208**) can be used on which the optical connector **204** can be mounted, where each such slider can be moved in the directions indicated by **214**.

FIGS. **3**A-**3**B depict a connector infrastructure **302** that has multiple connector modules **202**. The connector infrastructure **302** has a support frame **304** to which the connector modules **202** are mounted, either directly or indirectly. In FIGS. **3**A-**3**B, and in the various other figures discussed below, optical fibers connected to the optical connectors are omitted from the figures for better clarity. A connector module **202** can be mounted to the support frame **304** using any of various types of attachment mechanisms, such as an attachment mechanism including pins arranged in corresponding grooves, or other types of attachment mechanisms. The connector modules **202** are each slideable with respect to the support frame **304**.

The support frame **304** has a first segment **304-1** and a second segment **304-2** that is angled with respect (e.g. generally perpendicular) to the first segment **304-1**. The second segment **304-2** of the support frame **304** has openings **308** through which respective optical connectors **204** of the connector modules **202** can extend. When a connector module **202** is in its retracted position, the corresponding optical connector **204** of the retracted connector module **202** is retracted within the support frame **304** of the connector infrastructure **302**, and sits behind the opening **308** such that the optical elements of the optical connector **204** are protected from impacting other objects.

To actuate a connector module **202**, a user can grip the corresponding actuator **212** to move the connector module **202** towards the second segment **304-2** of the support frame **304**. As shown in FIG. **3**B, the lower five connector modules **202** are shown in their extended position, in which the optical connectors **210** of each of these connector modules **202** have been pushed through respective openings **308** of the second segment of **304-2** of the support frame **304**. When a given connector module **202** is in its extended position, its corresponding optical connector **204** protrudes outwardly from the support frame **304**. Moving the optical connector **204** through the corresponding opening **308** of the support frame second segment **304-2** allows the optical connector **204** to be exposed to allow the optical connector **204** to mate with the optical connector of the respective electronic device.

In FIG. **3**B, the uppermost connector module **202** remains in its retracted position. Thus, it can be seen that a user can selectively and independently move the connector modules **202** between the retracted position and extended position. In other words, one of the connector modules **202** can be moved from a retracted position to the extended position, while another of the connector modules **202** remains in the retracted position. Similarly, one of the connector modules **202** can be moved from the extended position to the retracted position while another of the connector modules **202** remains in the extended position.

As depicted in both FIGS. **3**B and **3**C, each actuator **212** is slideable in a respective slot **330** in the first segment **304-1** of the support frame **304**. FIG. **3**C provides a view of a side of the connector infrastructure **302** that is opposite to the view provided in FIG. **3**B. Also, in FIG. **3**C, the first segment **304-1** of the support frame **304** is made transparent to allow viewing of the connector modules **202** behind the first segment **304-1**. The slot **330** extends generally parallel to the axis **214** shown in FIG. **2**, such that each connector module **202** can be moved back and forth along the axis **214**.

Also, in examples according to FIG. **3**C, a handle **332** is further attached to each actuator **212**—a user can grab the handle **332** instead of the actuator **212** to move the actuator **212** along the slot **330**. In other implementations, a lever can be used instead of the handle **332** to move a connector module **202**.

As shown in FIGS. **3**A and **3**B, in addition to the connector modules **202**, the connector infrastructure **302** further includes another connector module **322** that has an optical connector **320** for optical connection to a corresponding optical connector of another connector infrastructure. The connector module **322** is slideable along a slot **326**, which extends along a direction that is different from a direction of the slots **330**. In some examples, the slot **326** extends in a first direction that is generally perpendicular to a second direction of the slots **330**. The connector module **322** has an actuator **324** that can be gripped by a user to slide the connector module **322** along the slot **326** (between a retracted position and extended position of the connector module **322**). The configuration of the connector module **322** that is slideable in the slot **326** is similar to the configuration of the connector module **202** that is slideable in the slot **330**, discussed above.

FIGS. **3**A-**3**B illustrate an example connector infrastructure **302** in which the connector modules **202** are each individually and independently moveable with respect to each other. In other implementations, as shown in FIG. **4**, groups of two or more connector modules **202** can be moved in tandem. In FIG. **4**, three such groups are provided, including a first group that includes the upper two connector

modules **202**, a second group that includes the middle two connector modules **202**, and a third group that includes the lower two connector modules **202**. The connector modules **202** of each group are fixed with respect to each other (either directly or indirectly), such that the connector modules in the group are moved together (in tandem) between the retracted position and the extended position.

Fixing one connector module to another connector module can be accomplished by using an attachment mechanism to attach the multiple connector modules in fixed relation with one another. For example, a plate can be used that attaches to the multiple connector modules in a group.

In alternative examples, instead of affixing connector modules in a group to each other, an individual connector module can have multiple optical connectors. In other words, instead of groups of multiple connector modules, each group can be considered an individual connector module if this connector module has a slider on which is mounted multiple optical connectors.

FIGS. **5**A-**5**C are rear schematic perspective views of an array of electronic devices **502** and a connector infrastructure **302** according to some implementations. FIG. **5**A shows an arrangement in which the connector infrastructure **302** is spaced apart from the electronic devices **502** (and thus not yet engaged with the electronic devices **502**). Each electronic device **502** has a respective optical connector **504**, which is configured to mate with the optical connector **204** of the corresponding connector module **202** in the connector infrastructure **302**.

FIG. **5**B shows initial engagement between the connector infrastructure **302** and the connectors **504** of the electronic devices **502** as the connector infrastructure **302** is brought into engagement with the array of electronic devices **502**. After the initial engagement depicted in FIG. **5**B, a user can selectively actuate the connector modules **202** of the connector infrastructure **302** to push the optical connectors **204** of the respective connector modules **202** through openings in the front segment **304-2** (FIG. **3**B) of the support frame **304** such that the optical connectors **204** can mate with the optical connectors **504** of the corresponding electronic devices **502**. FIG. **5**C shows all of the connector modules **202** of the connector infrastructure **302** engaged to the array of electronic devices **502**.

The optical connection between the electronic device **502** and the connector modules **202** can be a blind-mate optical connection. A "blind-mate optical connection" refers to an optical connection in which one connector can be connected to another connector, with alignment between the connectors being automatically performed using alignment features, such that a user does not have to visually align connectors to make the connection.

FIGS. **6**A-**6**C provide a different perspective view of a portion of the array of electronic devices **502** and the connector infrastructure **302**, at positions corresponding to those shown in FIGS. **5**A-**5**C, respectively. In each of FIGS. **6**A-**6**C, a portion of the uppermost electronic device **502** has been cut away to provide a better view of two of the optical connectors **504**, and their corresponding engagement with connector module optical connectors **204** (as shown in FIGS. **6**B and **6**C).

FIGS. **7**A-**7**B provide different perspective views of a system having a two-dimensional array of electronic devices **502** connected to various respective connector infrastructures **702**, **704**. Each connector infrastructure **702** and **704** is arranged similarly to connector infrastructure **302** (discussed above). However, in examples according to FIGS. **7**A-**7**B, the connector infrastructure **702** is provided with an interconnecting optical connector **706** for optical connection with a corresponding interconnecting optical connector **708** of the connector infrastructure **704**.

The interconnecting optical connector **706** is provided on a slider **724** that is slideable along a slot **726** in the support frame **703** of the connector infrastructure **702**. Similarly, the interconnecting optical connector **708** is provided on a slider **728** that is slideable along a slot **730** in the support frame **705** of the connector infrastructure **704**. The sliders **724** and **728** that are slideable in respective slots **726** and **730** are similarly configured as the slider **208** and slot **330** discussed above in connection with FIGS. **2** and **3**A-**3**C.

Thus, as shown in FIGS. **7**A and **7**B, pairs of connector infrastructures (**702**, **704**) are connected to each column of electronic devices **502**. The connector infrastructures (**702**, **704**) in each pair are optically connected to each other using the interconnecting optical connectors **706** and **708**. In addition, the connector infrastructure **702** further has an interconnecting optical connector **710** for connecting to a bridge connector infrastructure **712**. The bridge connector infrastructure **712** is further optically connected to interconnecting optical connectors **710** of the other two connector infrastructures **702** depicted in FIGS. **7**A and **7**B. The bridge connector infrastructure **712** allows the electronic devices **502** to communicate with each other and with another entity that may be external of the system depicted in FIGS. **7**A and **7**B. The interconnecting optical connectors **710** are arranged on respective sliders **720** that are slideable along corresponding slots **722**. Such configuration is similarly to the configuration of the slider **208** and slot **330** discussed above in connection with FIGS. **2** and **3**A-**3**C.

The arrangement shown in FIGS. **7**A and **7**B provides a greater level of granularity, in that multiple ones of the connector infrastructures **702** and **704** are connected to respective subsets of electronic devices **502**. In this manner, an individual connector infrastructure (**702** or **704**) can be removed without having to remove other connector infrastructures, which provides enhanced flexibility.

The ability to independent actuate individual or groups of connector modules in the connector infrastructures according to various implementations discussed above allows for easier connection/disconnection of connector infrastructures while reducing the likelihood of damage to optical connectors. Moreover, by employing multiple connector infrastructures (that are connected together) in a system (such as depicted in FIGS. **7**A-**7**B), scalability can be enhanced. Also, smaller connector infrastructures can be employed, which can improve ease of handling and shipping.

FIG. **8** is a flow diagram of a process of assembling a connector infrastructure (as discussed above) according to some implementations. The process of FIG. **8** can be performed at a manufacturing facility of the connector module **108**, or alternatively, the process of FIG. **8** can be performed by another entity for assembling the connector module **108**.

The process of FIG. **8** provides (at **802**) a support frame (e.g. support frame **304** shown in FIGS. **3**A-**3**B) of the connector infrastructure. The process then mounts (at **804**) multiple connector modules (e.g. **202** in FIGS. **3**A-**3**B) to the support frame, where the connector modules have respective optical connectors that are independently retractable and extendable.

In the foregoing description, numerous details are set forth to provide an understanding of the subject disclosed herein. However, implementations may be practiced without some or all of these details. Other implementations may include modifications and variations from the details dis-

cussed above. It is intended that the appended claims cover such modifications and variations.

What is claimed is:

1. A connector infrastructure comprising:

a support frame comprising a plurality of first slots and a second slot, the second slot extending in a direction generally perpendicular to a direction of the first slots;

a plurality of connector modules mounted to the support frame and having respective optical connectors to optically connect with respective electronic devices, wherein the optical connectors are moveable between a retracted position and an extended position along respective slots of the first slots, and wherein the optical connector of a first of the connector modules is retractable and extendable independently of a second of the connector modules; and

a further connector module slideable between a first position and a second position along the second slot.

2. The connector infrastructure of claim **1**, wherein the further connector module when in the second position is to connect to a connector module of a second connector infrastructure, and wherein the further connector module when in the first position is disconnected from the connector module of the second connector infrastructure.

3. The connector infrastructure of claim **2**, wherein the further connector module comprises an optical connector.

4. The connector infrastructure of claim **1**, wherein the first connector module is part of a first group of the plurality of connector modules, and the second connector module is part of a second group of the plurality of connector modules, and wherein the optical connectors of the first group are retractable and extendable together independently of the optical connectors of the second group.

5. The connector infrastructure of claim **1**, wherein the support frame has openings through which respective ones of the optical connectors of the plurality of connector modules are to extend when the respective connector modules are in the extended position.

6. The connector infrastructure of claim **1**, wherein each of the plurality of connector modules has an actuator that is user-actuatable to move the corresponding connector module between the retracted position and the extended position, and the further connector module has an actuator that is user-actuatable to move the further connector module between the first position and the second position.

7. The connector infrastructure of claim **1**, wherein the further connector module is moveable along the direction of the second slot, and the plurality of connector modules are moveable along the direction of the first slots.

8. A system comprising:

a first connector infrastructure comprising:

a support frame;

a plurality of connector modules mounted to the support frame and having respective optical connectors to optically connect with respective electronic devices, wherein the optical connectors are moveable between a retracted position and an extended position along a first direction, and wherein the optical connector of a first of the connector modules is retractable and extendable independently of a second of the connector modules; and

a further connector module mounted to the support frame, wherein the further connector module has an optical connector and is movable between a retracted position and an extended position along a second direction that is generally perpendicular to the first direction; and

a second connector infrastructure having a connector module to optically connect to the optical connector of the further connector module.

9. The system of claim **8**, wherein the connector module of the second connector infrastructure is moveable between a retracted position and an extended position.

10. The system of claim **8**, wherein the support frame comprises:

a first portion including slots along which corresponding ones of the plurality of connector modules are slideable, and

a second portion angled with respect to the first portion, the second portion having openings through which corresponding ones of the optical connectors of the plurality of connector modules extend when in the extended position.

11. The system of claim **10**, wherein the first portion includes a further slot along which the further connector module is slideable.

12. The system of claim **8**, wherein the support frame includes first slots extending along the first direction, and a second slot extending along the second direction, the optical connectors of the plurality of connector modules moveable along respective slots of the first slots, and the further connector module moveable along the second slot.

13. The system of claim **8**, further comprising a bridge connector infrastructure optically connected to the second connector infrastructure, the system further comprising:

a third connector infrastructure comprising:

a support frame;

a plurality of connector modules mounted to the support frame of the third connector infrastructure and having respective optical connectors to optically connect with respective electronic devices; and

a further connector module mounted to the support frame of the third connector infrastructure, wherein the further connector module of the third connector infrastructure has an optical connector to optically connect to the bridge connector infrastructure.

14. The system of claim **8**, further comprising the electronic devices, wherein selected ones of the plurality of connector modules are moveable to the extended position to optically connect to the electronic devices while leaving others of the plurality of connector modules in the retracted position, the connector modules in the retracted position not optically connected to the corresponding electronic devices.

15. A method of assembling a connector infrastructure, comprising:

providing a support frame;

mounting a plurality of connector modules to the support frame, the connector modules having respective optical connectors to optically connect with respective electronic devices, wherein the optical connectors are moveable between a retracted position and an extended position along respective first slots of the support frame, the first slots extending in a first direction, and wherein the optical connector of a first of the connector modules is retractable and extendable independently of a second of the connector modules; and

mounting a further connector module to the support frame, the further connector module moveable along a second slot between a retracted position and an extended position, the second slot extending in a second direction generally perpendicular to the first direction.

16. The method of claim **15**, wherein the further connector module when in the second position is to connect to a

connector module of a second connector infrastructure, and wherein the further connector module when in the first position is disconnected from the connector module of the second connector infrastructure.

17. The method of claim **16**, wherein the further connector module comprises an optical connector.

18. The method of claim **15**, further comprising providing openings in the support frame through which respective ones of the optical connectors of the plurality of connector modules are to extend when the respective connector modules are in the extended position.

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